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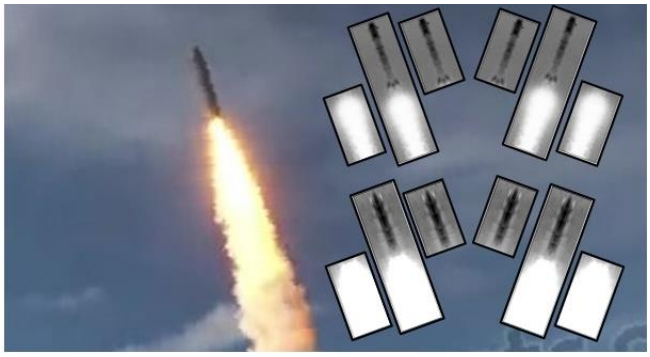
Rocket Type and Attitude Detection from Airborne Imagery: a case study

In recent years, we the Brainlike Team, have developed a commercial product called PixMin, along with an accompanying analyst development kit (ADK).



The PixMin ADK enables analysts to build templates *a Priori*, like those shown on the right side of this figure. The PixMin ADK runs the PixMin engine, which moves each template over the image in the figure background very quickly. For each template and at each of its locations within the image, PixMin computes a matching value, using one or more matching value metrics available in the ADK. The PixMin ADK and engine include a variety of provisions for filtering out background clutter to produce robust results. In this case study, we used PixMin in conjunction with the ADK to show how PixMin can classify images according to rocket type and orientation.
Here are use-case details.

a) We scanned the Internet for appropriate use-case imagery. The website we selected was Shutterstock because its missile offerings, as shown in the background frame below, had the most suitable video clips for our use-case.
b) We selected video clips from the website for the two missile types shown, based on their clarity and similarity. We selected and downloaded the clip for Type A , including the image shown in the lower left corner of Figure 2. We selected the clip for type B, including the image shown in the the lower right corner of Figure 1.

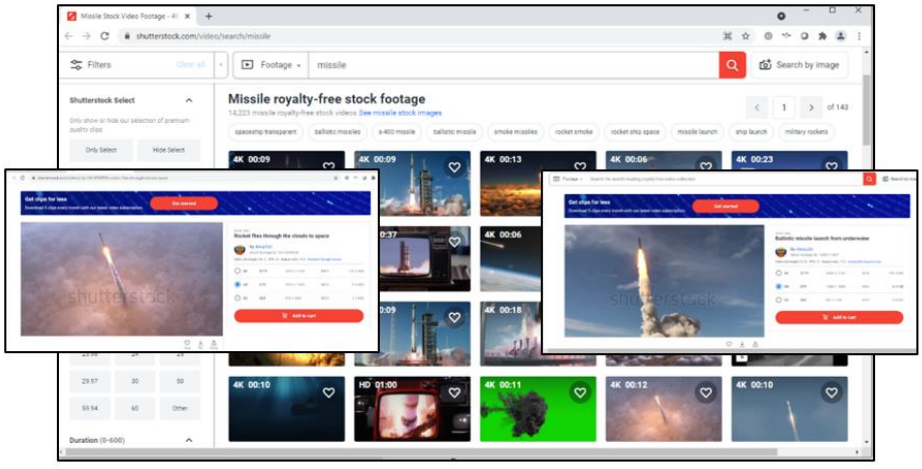


Figure 1. Use-Case Imagery Website and Selected Video Clip Frames

c) Within each of the two types, we selected three frames. We cropped, resized, rotated, and flipped two of the frames within each type as necessary to make up the sample of frames shown in the left column in Figure 2 below. We used the remaining frame within each type to make a triplet of template versions for each type, rotation combination, shown at the top of Figure 1. Each triplet includes a full template, a flame template, and a body template, as shown. We built these templates from the remaining (non-sample) frames using the missiles' basic shapes along with template standard PixMin development methods.

d) We used our "PixMin" precursor toolkit and engine to produce the Figure 1 results.

e) We used currently operational PixMin configurations to produce robust results under the varying image backgrounds shown.

f) We used PixMin standardizing options to control templates and images for differences in brightness and contrast.

g) We converted each set of red, green, and blue (RGB) triplet values for each pixel to one gray scale value to control for color.

h) We used sums of absolute difference (SAD) values to compute matches between each template and each of its homologous pixels within each test image. Lower SAD values indicate better matches than higher SAD values. We standardized the SAD values to make them comparable over images.

i) We used available PixMin template rotation options to produce rotated templates.

j) We used special PixMin coding features that enable high speed template scanning, rotation, and scaling. PixMin readily classify these images as shown in real time..

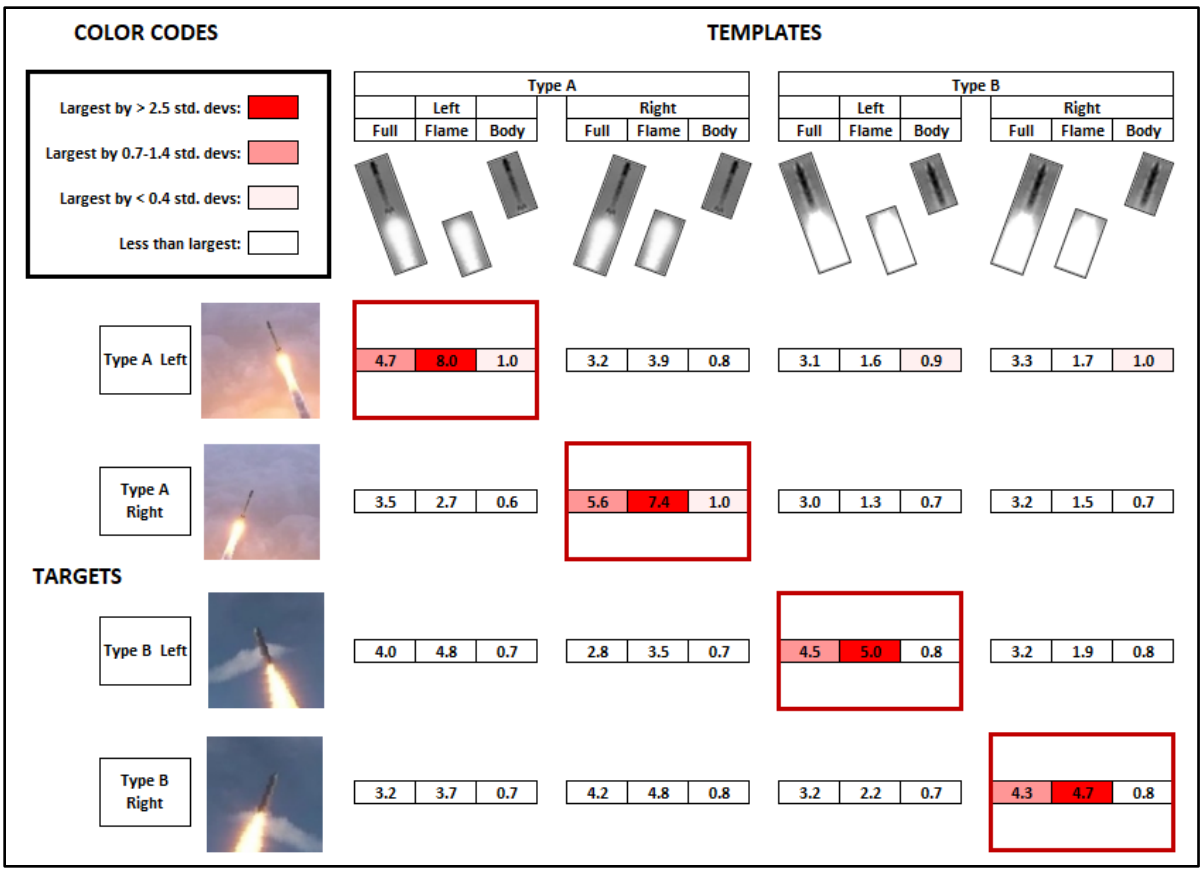


Figure 2. Target Classification Results.

Figure 2 summarizes results from a target demonstration example. We produced twelve *a Priori* templates, shown at the top of the figure, to evaluate the types and attitudes of missiles within four images, shown on the left side of the figure. Each number in the figure is a matching value for its row target missile based on its column template. The colored numbers in each column have the highest magnitudes for that column, in keeping with the color codes in the top, left box. As shown by the pink numbers, each full template correctly identified its corresponding missile and attitude. As shown by the red numbers, each flame template correctly identified its corresponding missile and attitude more significantly. As shown by lightest numbers, template numbers were less significant and they misclassified targets in two instances.

Evidently as shown by the templates, missile bodies were the weakest classifiers because they didn't look much different. By contrast, missile flames were the strongest classifiers because they looked more different. Full missile templates were the second strongest classifiers because they combined missile flame strength with missile body weakness.

These results offer promise for PixMin classification in terms of both their high precision potential and their straightforward analysis potential. Using the PixMin ADK, we produced statistically significant correct classifications by fitting simple templates to only a few target snapshots. Producing more sophisticated templates and combining results from repeated snapshots would have produced even more precise classifications. Regarding analysis potential, we have shown how PixMin can readily evaluate individual and combined templates. We took less than a day to produce these results on a laptop computer, based on the small sample shown. We would expect others using conventional, cloud-based machine learning methods to take far more analysis time and effort, requiring much larger training samples and much more powerful cloud-based servers.

We stand ready to deliver image results like those we demonstrated in this use-case for a broad variety of image classification solutions—quickly and affordably. For more information feel free to contact us.